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SHORE PROTECTION IN THE REPUBLIC OF THE MARSHALL ISLANDS - PILOT PROJECT REPORT

Report to the Federal Republic of Germany Federal Foreign Office Task Force for Humanitarian Aid

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SUMMARY

Wind, Wave, and Solar powered shore protection and coral reef restoration projects were installed in the Marshall Islands in early 2010 by the Arno Kobamaron Community Base Organization, in collaboration with the Global Reef Alliance and Pacific Aquaculture Cooperatives, funded by the Federal Republic

of Germany Federal Foreign Office Task Force for Humanitarian Aid. The projects were installed at Ine Village, Arno Atoll (Wind powered), Jabo Village, Arno Atoll (Wave powered), and Enemanit, Majuro Atoll, (Solar powered). Local community residents were trained in construction and installation skills. These projects will help restore near-shore coral reefs and fisheries habitat, protecting beaches from wave erosion and allowing them to grow. A tidal current project was originally also planned but unfortunately could not be installed during the project period due to delays by the manufacturer. The results of these pilot demonstration projects dramatically demonstrate that local communities can use their own vast and untapped sources of sustainable energy to grow back their coral reef and fisheries resources and protect their islands from erosion by global sea level rise. There is a critically urgent need to replicate this example on a large scale in all low-lying island nations and coasts before global sea level rise accelerates.

INTRODUCTION: ORIGIN OF PROJECT

Low islands and coasts all around the world are severely threatened by erosion and flooding due to rising global sea levels, currently increasing at 3.4 mm/year and expected to greatly accelerate in coming decades.

Current methods of shore protection are costly failures that need to be constantly rebuilt as they collapse, and which speed the erosion of sand in front of them. Use of seawalls have resulted in the almost total loss of the sand beaches that used to lie in front of developed areas. In many atolls the roads or paths that connect communities are washing into the sea from both ocean and lagoon sides, threatening access of outlying communities to docks and health and education services in the larger villages.

In late December 2008 high tides inundated low islands across the entire Pacific Basin. In the Republic of the Marshall Islands (RMI), a low atoll nation in the central Pacific whose average elevation is 2 meters, hundreds of people were flooded out of their homes and a National State of Emergency was declared.

A BBC news article about the 2008 RMI flooding emergency was sent to Ursula Rommerskirchen of the Federal Republic of Germany (FRG) Ministry of Foreign Affairs by Dr. Thomas Goreau, President of the Global Coral Reef Alliance (GCRA), an international Non Governmental Organization (NGO) specializing in coral reef restoration, global climate change, and community-based coral reef management. Beatrix Ganter of the Ministry requested information about RMI NGOs that might be able to distribute disaster emergency aid from FRG. But the Ministry quickly realized that before suitable NGOs could be found and the aid sent from FRG to RMI, the high tides would have long gone down, and the aid would arrive far too late to be useful.

The Ministry, upon further reflection, felt that its humanitarian aid mission would be made far more cost-effective by investing more funding in steps that could prevent future disasters instead of sending disaster aid that is often too little and arrives too late to help those most at risk. They therefore invited GCRA to collaborate with a RMI NGO in a pilot demonstration project to grow coral reefs to protect RMI coastlines from erosion using Biorock® Technology.

Biorock® Technology, invented by the late German architect Wolf Hilbertz and developed by him and Dr. Goreau, uses safe low voltage electrical charges, which can be provided by renewable energy sources such as the sun, winds, waves, and ocean currents, to grow solid limestone structures of any size and shape in the sea. This is the only marine construction material that is self-repairing and gets stronger with age. Corals on Biorock reefs grow 2-6 times faster than normal, have 16-50 times higher survival following severe high temperature events, rapidly build up fish populations, and have grown back severely eroding beaches on low lying islands in the Maldives and Indonesia (W. Hilbertz & T. Goreau, 2009, Shore protection from global sea level rise, 9p., in T. J. Goreau & S. T. Nielsen (Eds.), The Green Disc: New Technologies for a New Future, Gibby Media Group, Spokane WA, USA).

GCRA contacted the Arno Kobamaron Community Base Organization, a RMI NGO focused on the development of Arno Atoll, and developed a collaborative

proposal to build demonstration wave, wind, solar, and tidal powered shore protection projects in RMI, which was accepted by the FRG as part of it's program in disaster management and adaptation to global climate change.

Figure 1. Collapsing sea wall in Majuro, RMI, made of gabion wire baskets with a layer of concrete. These are constantly collapsing and being rebuilt at tremendous expense. These sea walls have caused the complete loss of the beaches that once lined these shores.

RESULTS

1. Establishment of working facility

Due to the remote location, poor transportation, and total lack of local infrastructure (no paved roads, electricity, telephones, or mail) at the project sites on these small and poor islands, all materials needed had to brought in from outside and all working facilities had to first be constructed. A workshop facility was built, despite severe logistic difficulties.

Figure 2. Workshop facility constructed at Jabo Village, Arno. Katwel Jormelu is shown training the local team in use of a gas torch to bend steel bars to make Biorock shore protection modules.

Figure 3. A Biorock shore protection module, made from welded steel bars with shelves for growing corals and giant clams, waiting on the beach to be installed.

2. Wind project

A wind powered Biorock shore protection project was set up at Ine, Arno. A windmill was installed. Seventeen Biorock structures were built by trained local villagers. Nine of these were installed in the shallow back reef area in front of the beach during the first phase, with the remaining eight structures to be added a few weeks later after the first ones have grown. The first windmill installed, a novel state-of-the-art vertical axis windmill with helical blades supplied by Natural Currents Inc., failed after less than one day of operation due to faulty blades supplied by the manufacturer. A smaller conventional propeller type horizontal axis windmill was then installed to replace it. Within two days of the windmill power being connected, the structures' rust had disappeared on all but the uppermost portions most exposed to the air, and the bulk of the structures had turned white as limestone began to grow on them. Corals were transplanted onto them. In coming months local residents who participated in the construction and installation phases, as well as local school students, will add many more corals and giant clams to turn them into a mariculture project for future community earnings and to restore habitat for fisheries. The growth of these corals will further accelerate the shore protection capacity of the Biorock structures.

Figure 4. Installing the replacement windmill.

Figure 5. The windmill in place with guy wires attached.

Figure 6. The windmill first starting to spin.

Figure 7. Transporting wave protection modules to site in Ine.

Figure 8. Emplacing the module at the site.

Figure 9. Wind powered module has turned white with limestone except for the very top after only two days of wind power.

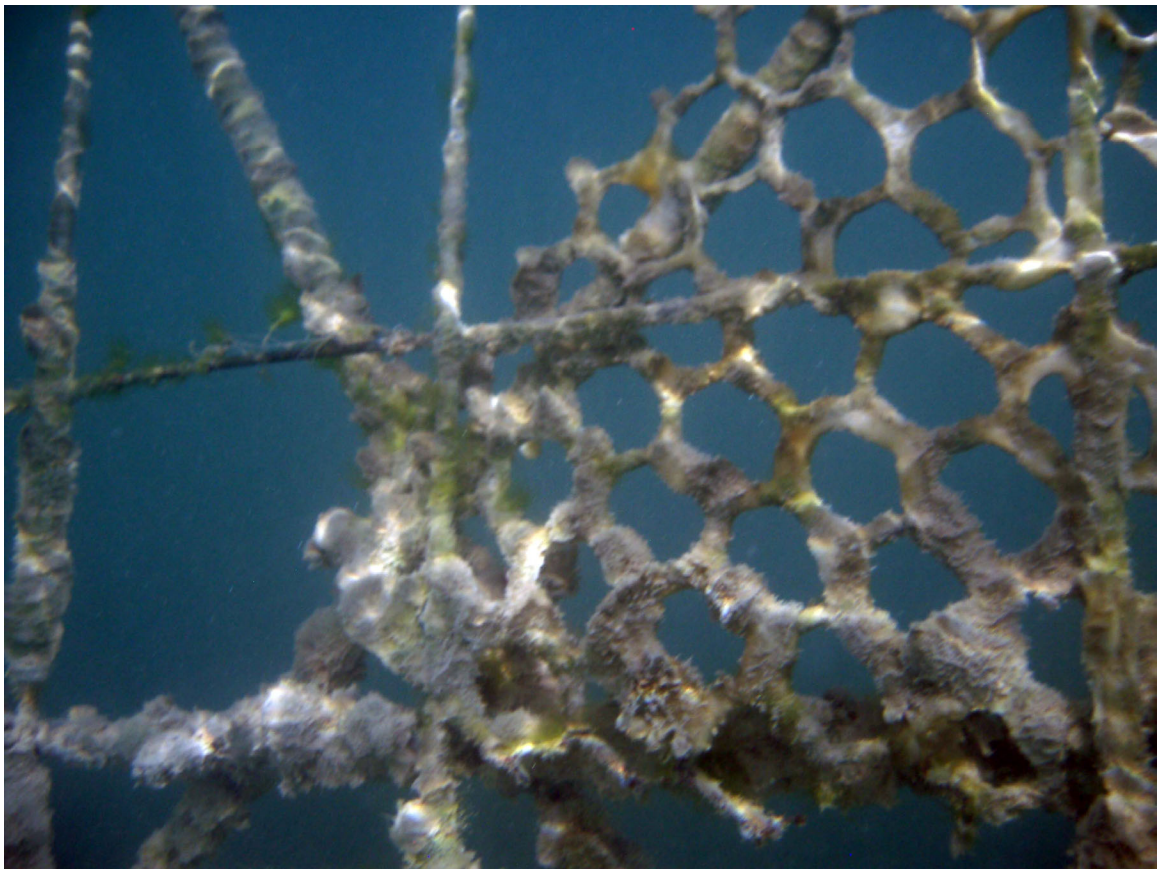


Figure 10. After just two days of wind power limestone minerals are growing over the reinforcing bars and wire mesh.

3. Wave project

A wave powered Biorock shore protection project was set up at Jabo, Arno. SwellFuel wave energy generators were assembled, installed, and moored. Five Biorock structures were built by a locally trained team. Within one day after connection to wave generators, the rust had disappeared on the steel bars, and white limestone growth became visible. Further growth will be followed by extensive coral transplantation, and the effect on beach growth monitored.

Figure 11. SwellFuel Wave Energy Generator installed in front of Jabo beach.

Figure 12. Transporting a shore protection module from Jabo Beach.

Figure 13. Preparing floats to move module to the correct location.

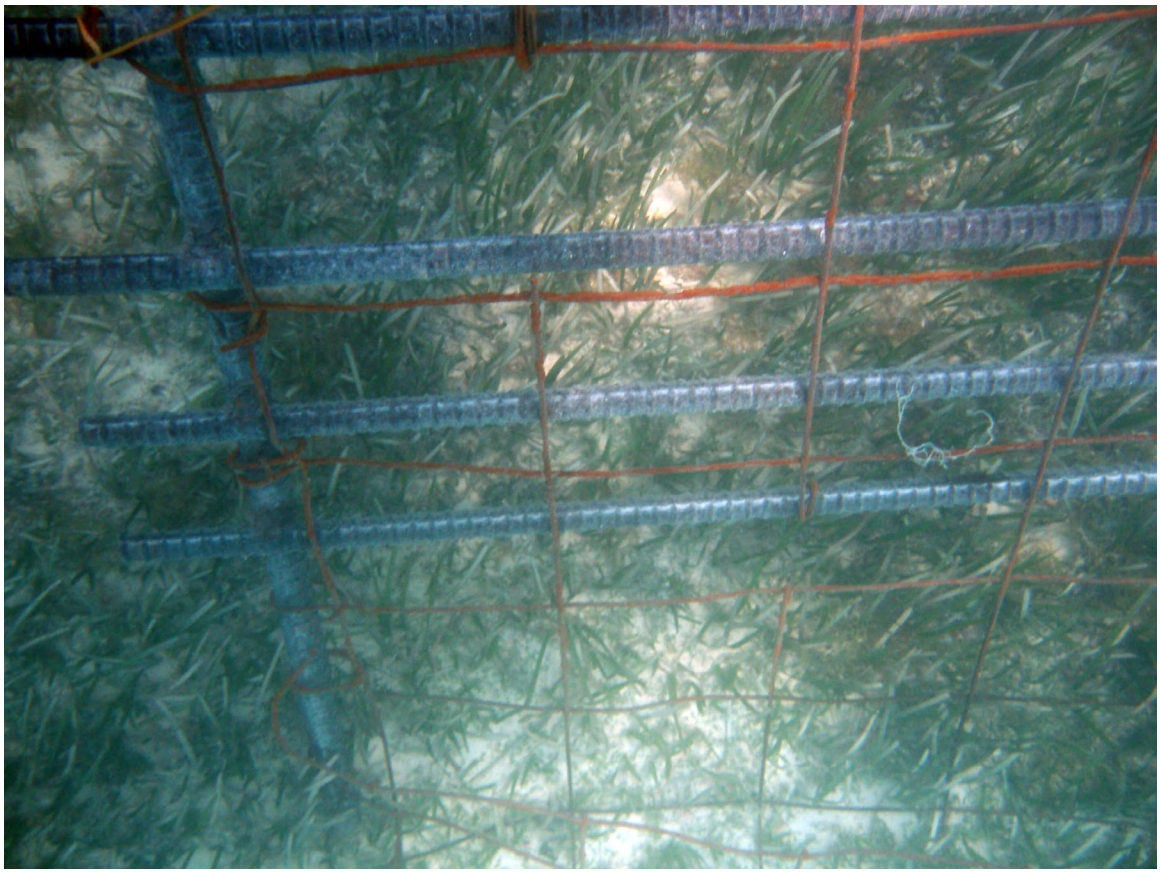


Figure 14. One day after connection to the wave generator, the rust has completely disappeared from the steel bar and they are turning white with new limestone mineral growth. The thinner mesh draws less power and is still rusted, but the rust is starting to reform and will also vanish in a few days.

4. Solar project

Three solar powered Biorock reef restoration structures were renovated at Enemanit, Majuro. These had been installed two years ago but had stopped working after cables from the solar panels to the structures were broken in a storm. The wiring was replaced and more corals added. Within three weeks there was noticeable new coral growth on all structures, the colors of the corals and giant clams became visibly brighter, and the number of fish around them about doubled or tripled.

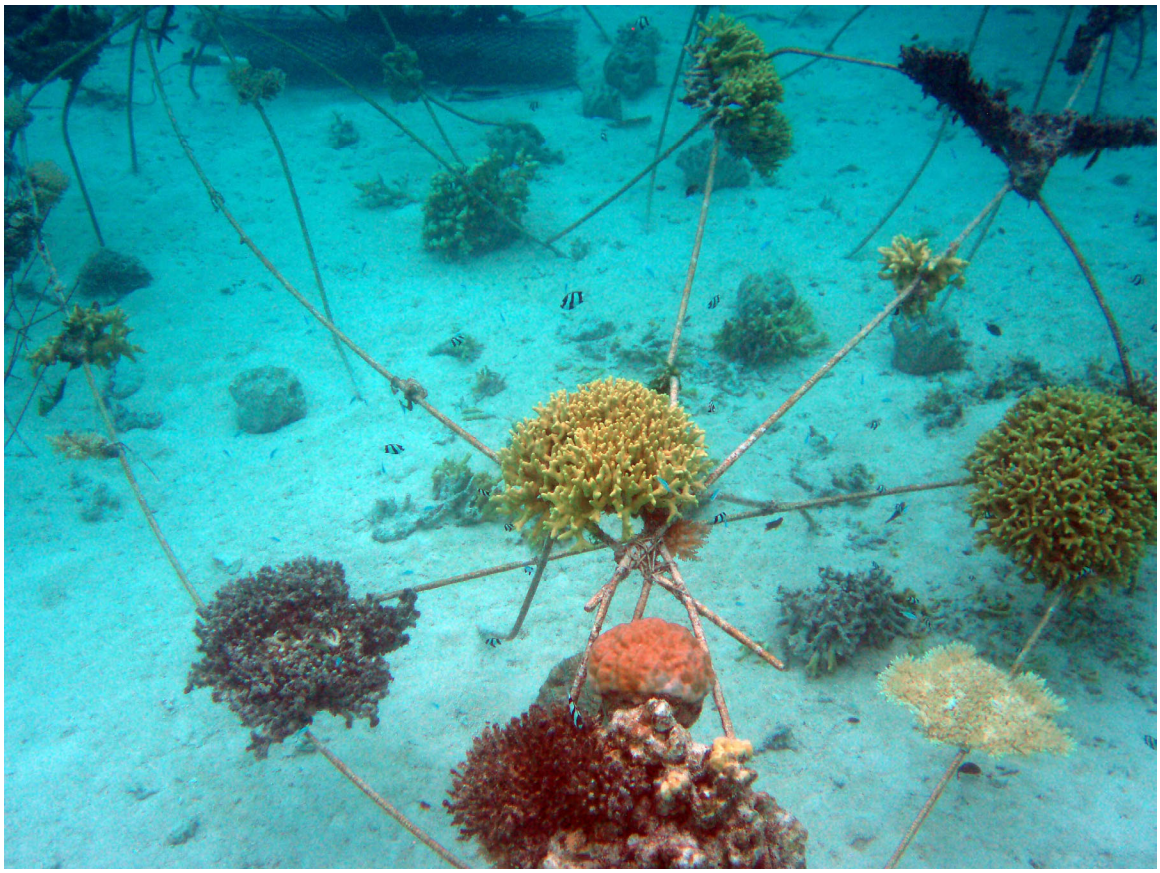


Figure 15. A solar powered reef structure at Enemanit.

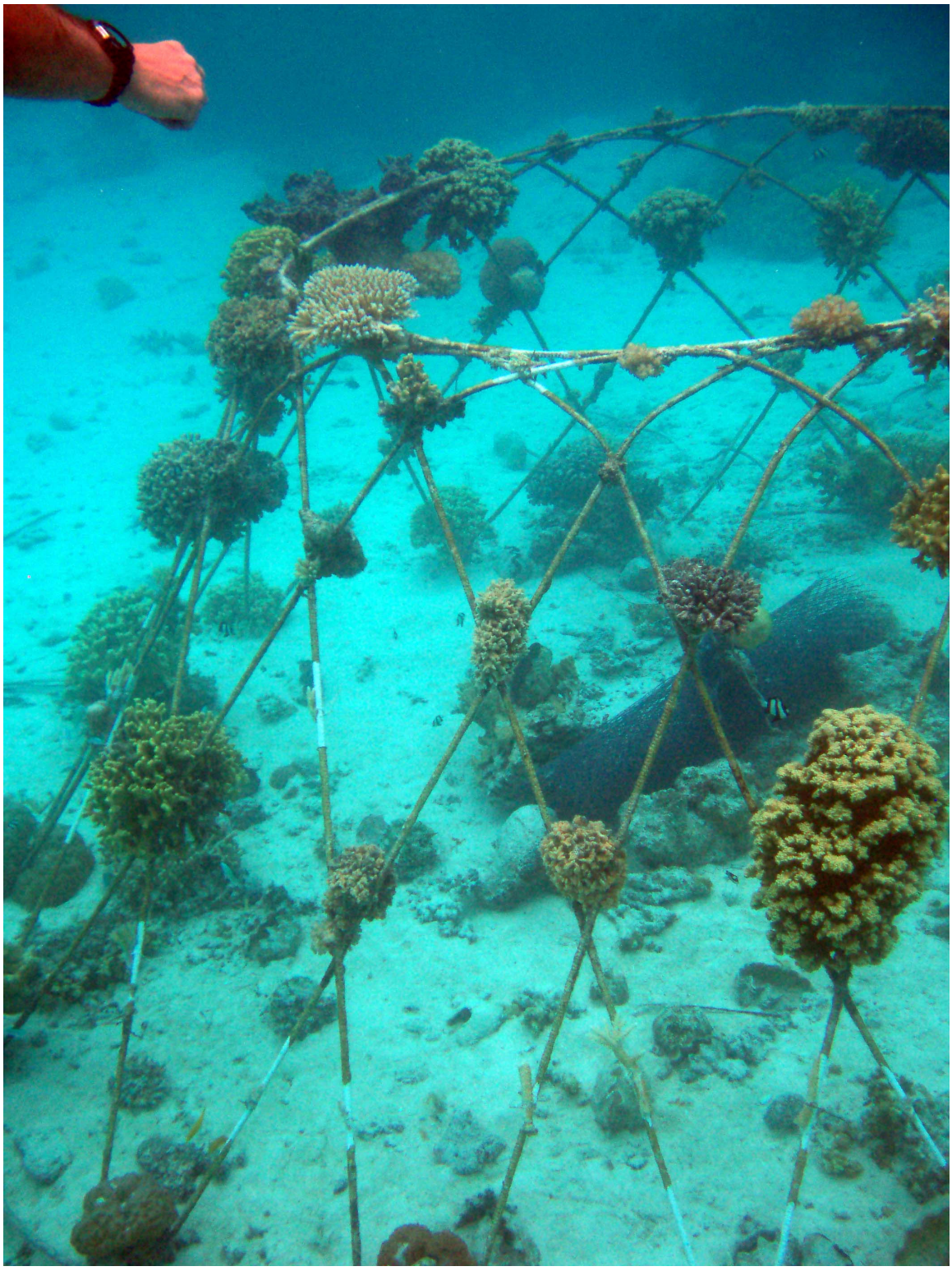


Figure 16. Another solar powered reef structure at Enemanit.

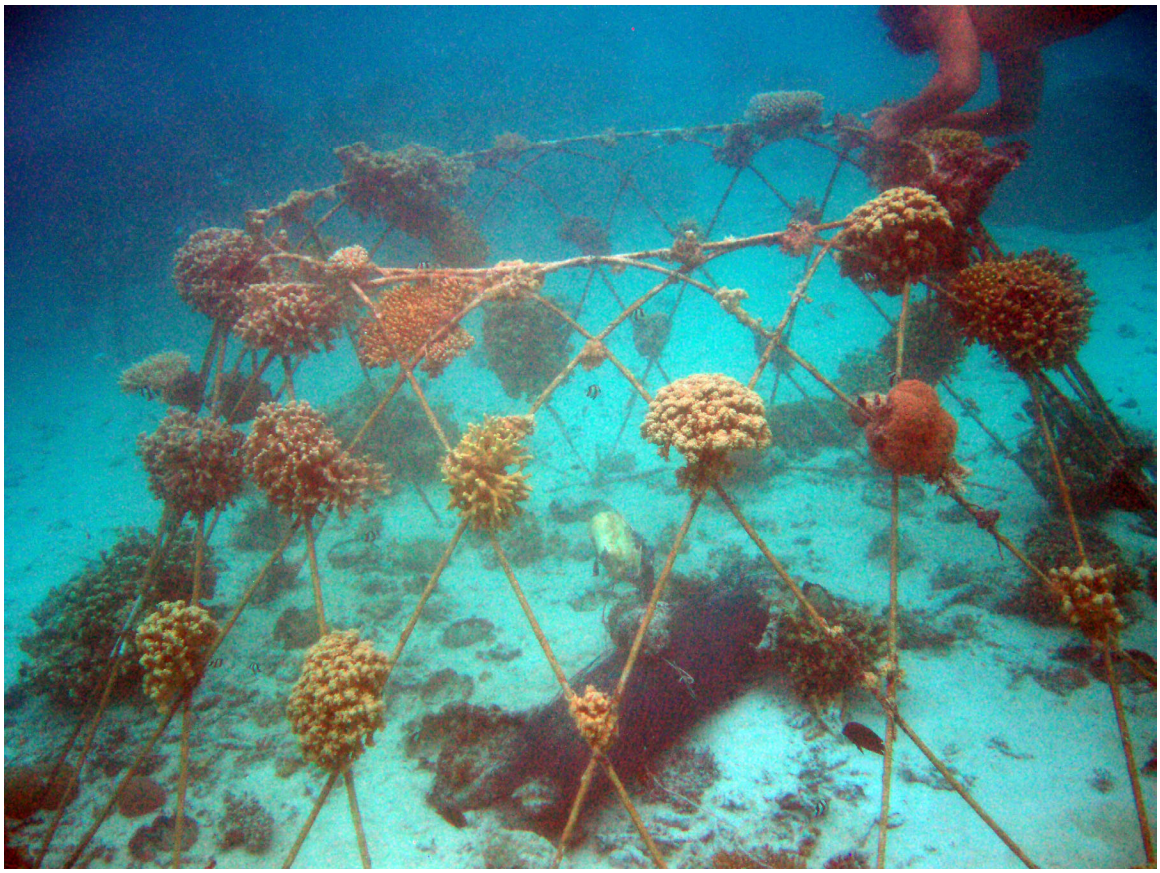


Figure 17. Corals grow at exceptional rates above the sandy bottom.

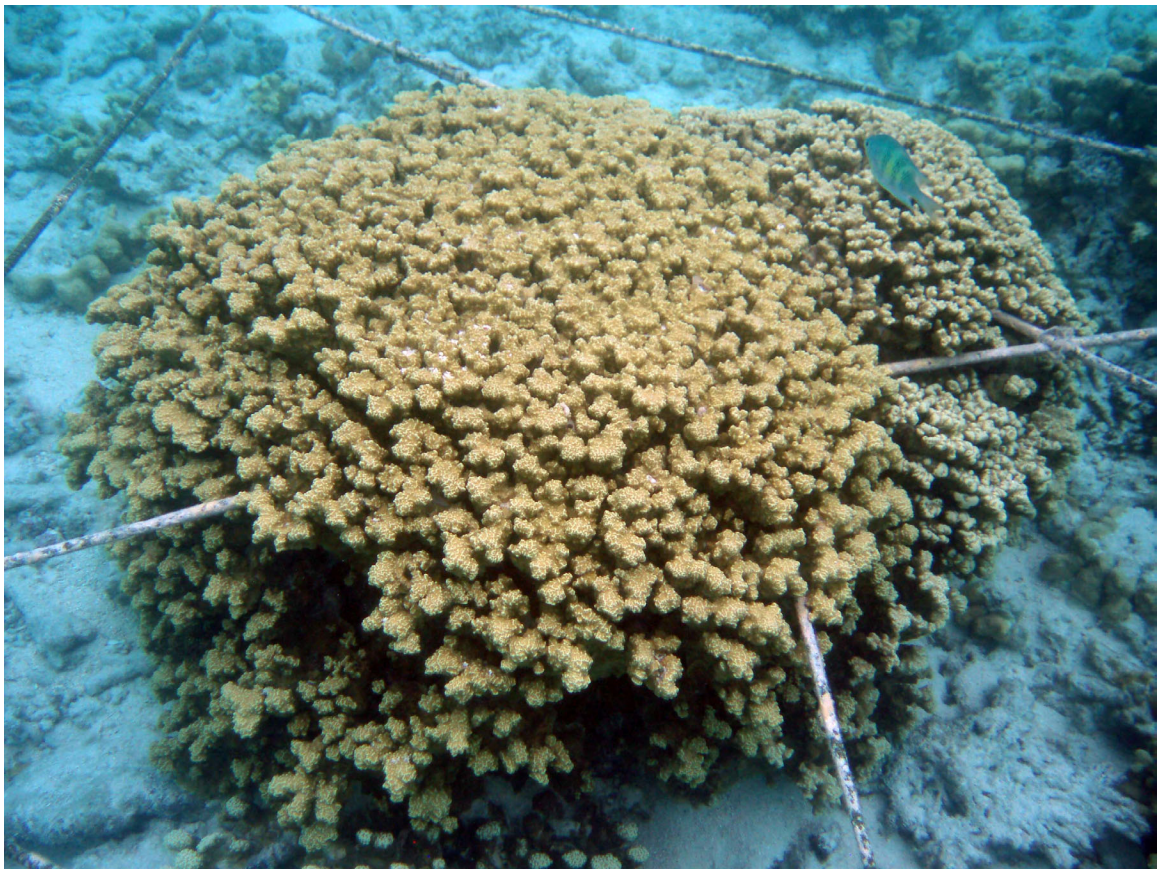


Figure 18. Solar powered corals grow so fast that they quickly overgrow the steel bars.

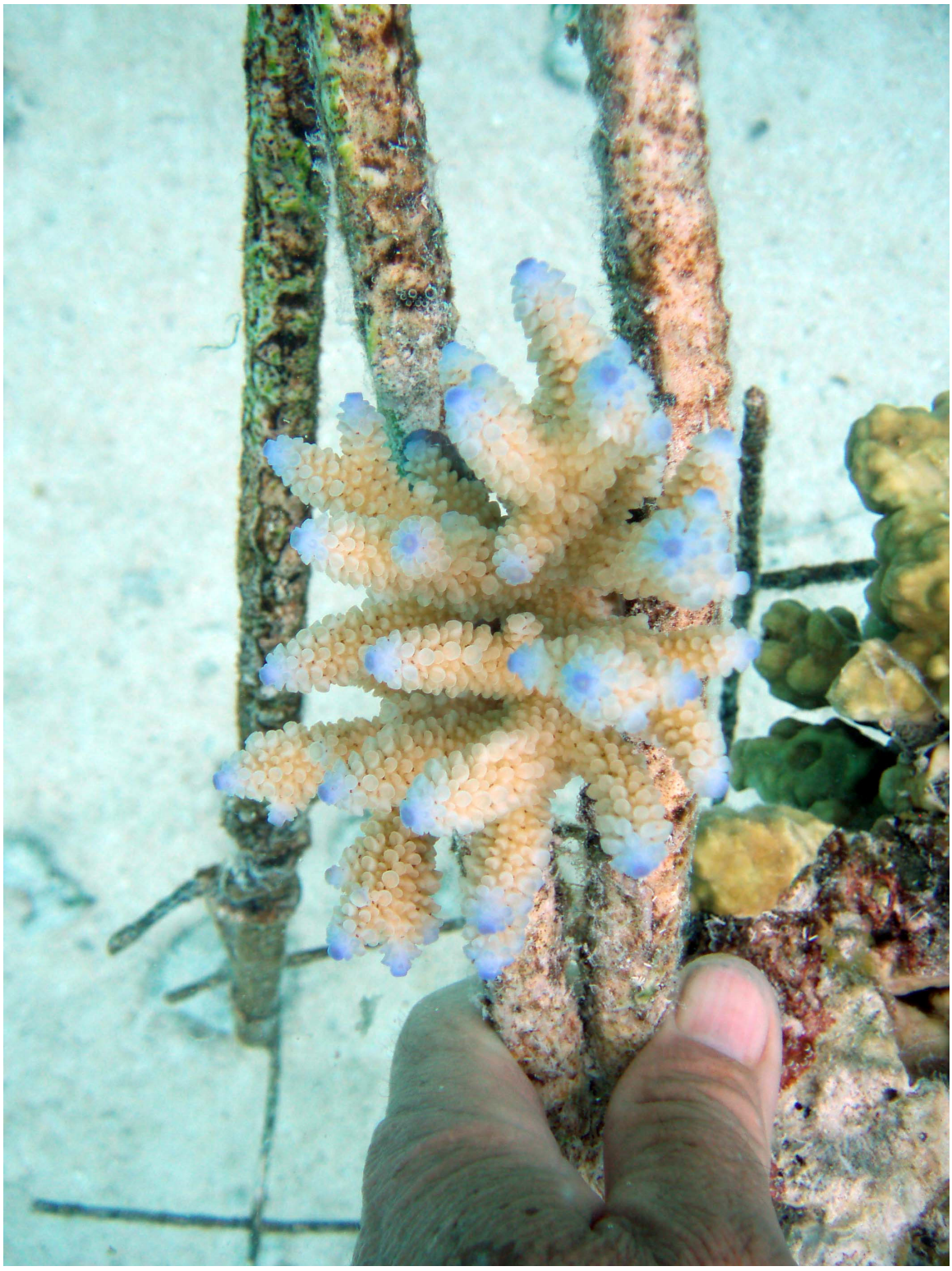


Figure 19. Closeup of a rapidly branching coral, grown from a single small tip.

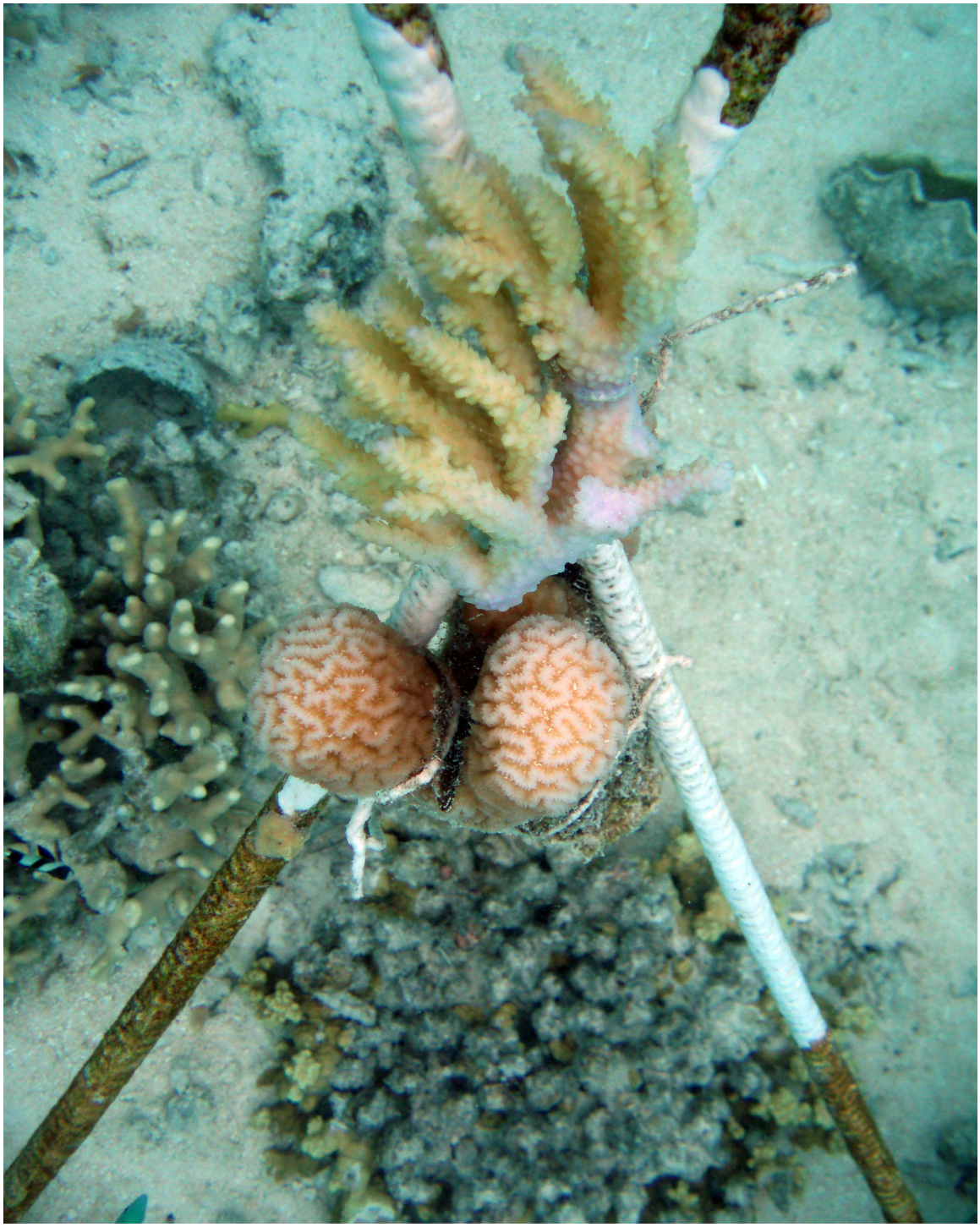


Figure 20. After three weeks, corals on the solar powered structure have cemented themselves onto the structure and are growing rapidly. The white material shows where the original limestone was broken off to attach them, and has grown back with fresh white material. The older limestone is brown because of a thin algae film.

Figure 21. Giant clams growing under the structure take on bright colors and beautiful patterns.

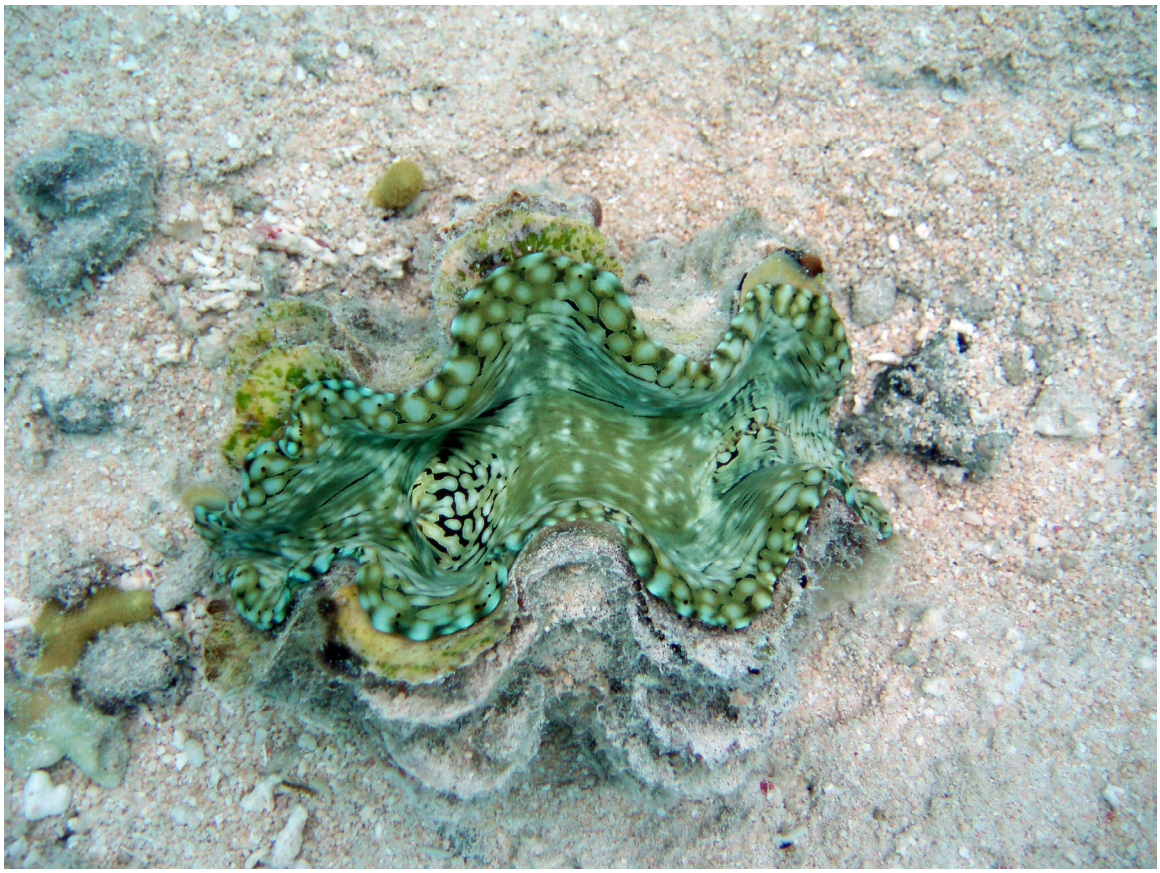


Figure 22. Each giant clam has a unique color and pattern.

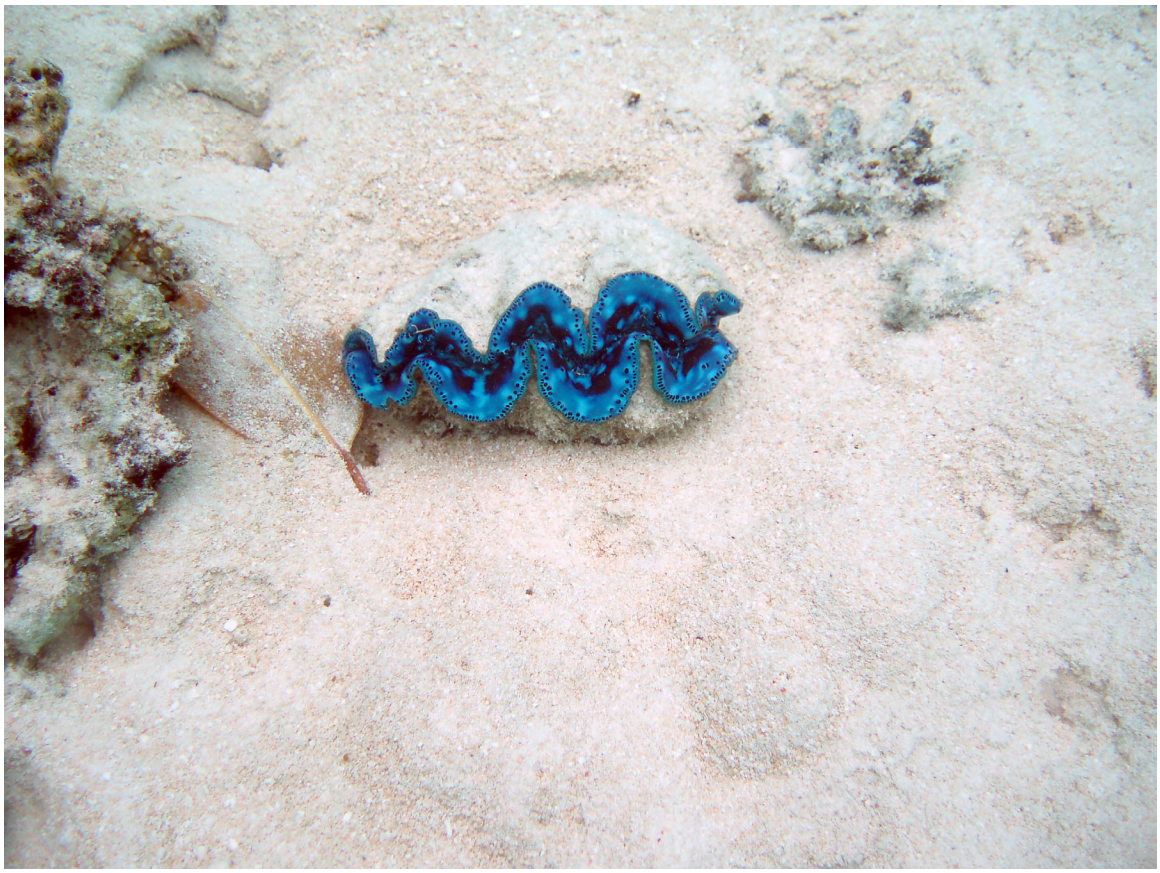


Figure 23. These clams had dull colors while the power had been off but became much brighter after the power was restored. These results show the tremendous potential of Biorock for giant clam mariculture for the aquarium trade and for food, as a new source of income for Marshall Islanders.

5. Tidal current project

The tidal current project could not be installed because the tidal current turbine was not delivered by Natural Currents Inc. before the end of the project due to unanticipated manufacturing delays. They have agreed to reimburse the funds provided to them for the tidal current turbine and float mounting. This will be used to pay the supervisory staff of the project, who worked on the project without pay and went into personal debt so that local labor could be paid and in order to purchase and install the replacement windmill from limited project funding.

6. Training

Local residents were trained in various aspects of steel bending, cutting, tying, construction, welding, and installation. They assisted the assembly and installation, and wiring of the wind, wave, and solar power systems.

7. Public education

Local residents were engaged in discussions of how to manage and combat shore erosion, sea level rise, coral reef protection, fisheries habitat restoration, mariculture, sustainable energy, and coastal zone management. Interviews were held about the project with the local press to prepare articles to disseminate the information to the wider national public (see last two pages of this report). A video about the project was shown at the United Nations Conference on Climate Change in Copenhagen in December 2009. Detailed photograph galleries were compiled for more information.

8. Climate change adaptation strategy

Meetings were held with the Minister of Resources and Development (Matt Zackhras), the Minister of Education (Nidel Lorak), The Ministry of Foreign Affairs Undersecretary for UN/International Affairs (Annette Note), the Chief of Staff of the Office of the President (Ruben Zackhras), and local leaders about climate change adaptation issues in RMI and the need to develop the country's vast and untapped sustainable energy resources so that they can grow back their reefs to provide food and protect their islands from erosion.

Figure 24. These children's future is what we are working to save.

Figure 25. We are really working for them!

Figure 26. If their beach vanishes, so will their island and their culture.

LESSONS LEARNED

1. Sustainable energy for shore protection of low lying coasts, adaptation to global climate change, and development

This project showed that abundant wind, wave, and solar energy is available along low lying coasts to grow limestone reefs in front of them to protect the coastlines from wave erosion and adapt to global sea level rise, while restoring coral reefs and fisheries and providing new mariculture opportunities. Moreover only a small portion of these energy resources are needed, showing that excess energy is available that could be generated to meet local development needs.

There is currently no electricity available on outer atolls except for Taiwanese donated solar panels on local houses, sufficient to provide a few lights at night. Prior to this only coconut husks provided cooking and light at night, unless people could afford imported kerosene. Electricity for other uses requires imported diesel fuel for generators. Since many outer atoll residents earn around $250 per year, such energy is totally beyond their reach. To have access to such services they must emigrate to Majuro, where around half the national population lives, largely outer atoll economic migrants seeking scarce jobs. A major portion of national import expenditures is on diesel fuel for the power plant that serves only Majuro, leaving all outer atolls without such services, thereby promoting crowding, pollution, and unequal development between Majuro and the outer atolls.

A better quality of living would result if outer atolls could use their own sustainable energy resources, with which all are equally endowed, equalizing economic development between atolls, and eliminating the largest single financial drain on the economy.

2. Community management capability

This small pilot project shows that outer islanders can readily learn the skills to protect their islands from sea level rise. Outer islanders' skills are largely confined to fishing by traditional methods and harvesting and processing coconuts to make copra. There is little opportunity to learn new skills or to earn money. Villagers in isolated subsistence communities quickly learned to build and install Biorock structures. They were eager to learn new methods and ideas, and to protect and restore their environment to be more productive.

Large scale shore protection projects to save entire islands from flooding by global sea level rise would need to employ the population in constructing shore protection projects that increase their fisheries production in the future. This could provide a pathway to increased sustainable earnings for the population. Arno is severely over-fished, for export to Majuro.

3. Remote operations

This project showed that it is possible to install a wide variety of state of the art sustainable energy generators to protect coastlines and restore marine resources even in extremely poor and remote areas with no economic development and infrastructure. Communities who have lived on atolls for thousands of years would rather protect what they have than become climate change refugees someplace else. This project showed that the tools exist to allow them to do so.

Incredible logistic obstacles and difficulties had to be overcome to successfully install this project, and this was only possible because of extremely hard and largely unpaid work, good planning and organization, access to the tools needed due to having first set up the needed working facilities, and willingness to adapt and innovate when equipment failed, because there was no possibility of getting further funding, equipment, materials, or supplies.

4. Adaptation to climate change

Faced with increasing sea level rise, the people of low lying islands must either tap their abundant but unutilized sustainable energy resources to grow back their coastal defenses, or they will lose their islands and be forced to become climate refugees. These pilot projects showed that it is feasible for trained local communities to protect whole islands and improve local fisheries as a side product of sustainable energy development, if the political will and financial resources for climate change adaptation are available. The choice lies between sustainable development or ultimate extinction of island resources and populations. Those who deny that climate change is happening and those who claim nothing can be done are in effect acting as allies promoting extinction of island cultures by preventing constructive adaptation in time to make a difference and avoid the inevitable consequences of failure to act.

RECOMMENDATIONS

1. We recommend that the results of this pilot project be greatly amplified in large-scale local community managed projects, both in Arno Atoll and in all inhabited low islands and coasts, to protect them from global climate change, as urgently as possible.

2. RMI could take the lead in developing policies to train and aid communities to save their islands by developing their sustainable energy and marine resources. FRG could take the lead in promoting effective anticipatory shore protection projects for climate change adaptation and disaster prevention, wherever they are needed.

3. To be most cost-effective such funding should go directly to community-based organizations organized to promote local education, training, construction, and marine sustainable resource management, including energy and fisheries.

4. At present the issue of adaptation to sea level rise is one of those "No Action, Talk Only" public relations opportunities, such as the UN Climate Change Conference. Policy makers and funding agencies have, with the exception of this project, acted as if climate change were not really underway and as if there were time to talk about it as a merely theoretical possibility instead of taking immediate action to deal with the impacts that have already hit, and which will certainly get much worse in the near future (probably suddenly and "unexpectedly") leaving affected communities with no resources to protect themselves.

5. Any further delay in implementing effective shore protection will simply make it impossible to adapt to or reverse the impacts that accelerating sea level rise will cause. Immediate large-scale action is needed!

For more information please check:

1) the article about the project in the Marshall Islands Journal (appended)

2) the project video made by Shaun Anderson McRae (NB this shows the original windmill before it failed, while the replacement one is shown in the report)

http://vimeo.com/8076742

3) the complete project photo galleries (NB there are 16 different photograph galleries on two index pages, organized thematically)

http://www.biorock.org/g23/v/marshall_islands/

Credits: Photos in this report by Tom Goreau.

CLIMATE CHANGE UPDATE

Innovation may

The coral-growing structure is 'walked' down the beach into position. Below, Arno residents secure the structure.
Photos: Dr. Thomas Goreau

An innovative shore protection project on Arno Atoll has received an enthusiastic evaluation by a representative of the German government, which funded the work. The "biorock" project, led by the Arno Koba Maron community group and directed by Dr. Thomas Goreau and Eric Hagberg, set out to demonstrate a method to protect an eroding shoreline from sea level rise using a mix of alternative energy.

GIFF JOHNSON

It integrates use of sustainable energy — wind, solar and wave — with training islanders to construct rebar and chicken wire platforms that are used to grow coral and which are expected — based on the already proven technology used in the Maldives by Goreau — to reduce wave impact and increase beach areas to protect coastal areas.

"We've been looking for something simple and sustainable (to address climate change)," said Carsten Muller, First Secretary of the German Embassy in the Philippines after his visit to Arno. "And we found it (at Arno)."

Carsten, who described Goreau as "one of the leading reef and shoreline protection experts in the world," spent two days reviewing the Arno project late last month, and came away effusive with praise. The German government injected 100,000 Euros (about US$130,000) into the work, which includes pilot projects at Ine and Jabo islands in Arno and on Enemanet Island in Majuro.

"It's so simple, it's hard to believe it works," Muller said. "Having seen how it works on the ground, I'm thrilled."

Low-lying islands from the Marshalls to the Maldives (in the Indian Ocean) have tried sea walls, gabions (rocks enclosed by chicken wire mesh) and sand bags to protect their shores from erosion, Goreau told the Journal. "They're a disastrous failure," he said.

At a hotel resort on an atoll in the Maldives in the early 2000s, Goreau said "we grew a reef in front of the island" using similar technology as at Arno. The metal structures are connected to low-voltage electricity, stimulating quick growth of the coral. As the corals grew on the rebar and chicken wire structures, the structures began slowing down the incoming waves.

"The waves still get to shore, but with less force and they deposit sand rather than taking it away," he said.

A side benefit of growing these reef structures is they create a new marine life habitat, drawing in fish and other marine life to the area. "It's an enormous tourist attraction," he said.

At this atoll resort in the Maldives, "now the beach is 50 feet farther out, where before the high tide came right up to the trees on the shore and the bungalows were in danger of falling into the lagoon," Goreau said.

Explaining the technology in use at Arno and Enemanit, Goreau said "we're using the same amount of power as a dim light bulb — about 30 watts."

Power on the two islands in Arno was generated by a windmill (Ine) and a wave generator (Jabo). A power cable is connected to the rebar structures in the lagoon, on which coral has been tied.

A result of the electrical current is it quickly reverses the rust process on the rebar, which turns white as limestone grows on it. With the stimulation of electricity, "corals grow exceptionally quickly," Goreau said.

Nine of these structures were built by Arno residents under Goreau and Hagberg's guidance and installed in the Ine lagoon.

CLIMATE CHANGE UPDATE

save the nation

Weakening the waves

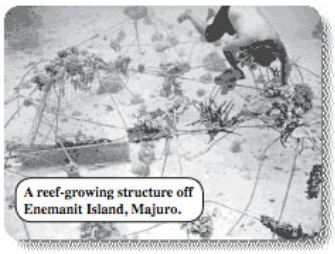
The principle of shore protection that Dr. Tom Goreau has piloted on Arno and at Enemanit is very different from what he describes as "traditional" shore protection of seawalls.

"A seawall absorbs the energy of the waves and sand disperses," he said. "The wave energy increases at the base of the seawall and washes away sand and undermines the structure."

He also noted how within a few years of installation, gabions (chicken wire baskets filled with rocks) are breaking open from wave damage in the RRE shoreline area and other places in which they are employed.

Goreau's shoreline protection project is building "open structures," so the waves go through. "The friction (as the waves move through the coral-filled structures) dissipates the energy of the waves," he said.

Goreau said these structures are much less expensive than seawalls.



A reef-growing structure off Enemanit Island, Majuro.

Arno's biorock project

Dr. Thomas Goreau is the President of the Global Coral Reef Alliance. His work has brought him to the Marshall Islands several times, most recently to oversee a pilot project of using "biorock" structures for shoreline protection at Arno Atoll. He works in islands from the Caribbean to the Indian Ocean.

His organization's web site contains information on the biorock system, which he Goreau has patented, and on climate change and reef issues. It can be accessed at: www.globalcoral.org.

Eight more have been built and are ready to be added. "One little windmill is powering the nine structures," Goreau noted.

The Jabo structures are using what he described as a state of the art wave generator — a box about the size of a large suitcase that is anchored to the lagoon floor and has an "arm" extending downward that moves back and forth with wave motion, generating electricity that is fed into the structures.

Three of these metal structures have been installed on Enemanit by Mike Trevor's place.

They are using solar power panels that are 40 years old, Goreau said. He noted that while the structures have been in the lagoon for a year, the power was only hooked up about three weeks ago.

When they were connecting the solar power to the structures, "we put some little coral fragments on the structure," Goreau said. They've already shown significant growth, he said.

Muller told the Journal, "this is not just a scientific experiment. It's a serious practical application."

Making it all the more impressive is Arno's "remoteness and the low-level of logistical support available," Muller said.

While the German funded part of the Marshall Islands project has ended, Muller said he will be submitting a report on this pilot project and hopes that "it can be extended to other locations. Germany is trying to be active in climate change work."

Untapped resources

There are completely untapped energy resources in the Marshall Islands that can be used for a range of sustainable development. That is one message coming out of the Arno shoreline protection "biorock" pilot project.

Power can be produced from the sun, waves, wind and tides, and "only a tiny fraction is needed for shoreline protection," said Dr. Thomas Goreau, who supervised the work at Arno.

"There has been no development on most outer islands because there is no power," he said. "But these islands are just as rich as Majuro. If they develop (sustainable power sources) they won't have to import diesel fuel. The Marshall Islands is rich in sustainable resources." The project effectively used wind, wave and solar power.

Other important developments from the pilot project include:

• It was done in a remote location with local residents who had no training and skills for the work. "They were trained to build the structures and tap sustainable energy," Goreau said. "They had no difficulties in learning techniques needed to save their islands and restore fisheries."

• Fish stocks in Arno are severely depleted from over-fishing, Goreau noted. The biorock structures help reestablish marine life by creating new habitats for fish.

Wind power and wave power are relatively untapped resources.

Action urgently needed

The Netherlands is about the only nation in the world that has a plan for dealing with sea level rise and climate change, says Dr. Thomas Goreau.

Low-lying areas such as the RMI, Kiribati, Tuvalu, Maldives, and Bangladesh, as well as the United States and other developed nations "have no plan," he said. But there are adaptive measures that can be implemented in the meantime to protect these islands, he said.

He believes the "two enemies to action on climate change" are people in complete denial and people who say it is hopeless. "Both prevent action, but action is urgently needed," he said.

The problem needs "a higher level of seriousness" from policy makers in countries throughout the world, and money to develop sustainable resources, he said.

The significance of the German-funded pilot project on Arno is that it is the first time to fund this type of project. "Internationally, there have been many promises of money for adaptation, but not much funding," he said. "The German-funded pilot project doesn't solve the problem, but it points us in the right direction."